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ECONOMIC AND MATHEMATICAL MODELING OF THE INNOVATION PROCESS IN THE AGRO-INDUSTRIAL SECTOR

It is known that econometric modeling is a powerful method of economic analysis and forecasting [1, 2, 3]. Therefore, the author considers it appropriate to use the above method in the dissertation work. To analyze and predict some indicators of the agro-industrial sector, trend models were built for such indicators as the volume of AIS production, the volume of AIS fixed assets, the volume of investment in AIS, the volume of value added created in AIS. In addition, an econometric model was constructed that describes the dependence of the volume of AIS production on the indicators of the volume of AIS fixed assets and the volume of investment in AIS. Note that the statistics of the indicator of the volume of innovative products are available only for 2011-2019, and at the same time they were subject to significant fluctuations, which did not allow for this indicator to build a statistically significant trend model with common economic sense.

The main information base of the dissertation work is presented below (Table 1).

Table 1

Information base of a number of AIS indicators, *million mans (in current prices)*

Years	Volume of agro-industrial products	Investments in AIS	Volume of fixed production assets	Volume of innovative products	Volume of added value
2000	736,6	41,0	6943,3	-	-
2001	811,2	15,6	7884,3	-	-
2002	839,3	7,2	9110,2	-	-
2003	1 063.4	13,5	11380,7	-	-
2004	1 098.6	8U	14198,9	-	-
2005	1265.8	42,8	1022,9	-	254,8
2006	1374,9	63,4	985,7	-	224
2007	1509.8	833	1071,1	-	282
2008	1669,6	82	1448,4	-	302,9
2009	1794,1	73,7	1615,8	-	540,8
2010	2225,7	96,4	2084,7	-	582,7
2011	2452,5	220,6	2186,7	3,9	644,4
2012	2923,1	203,1	2169,2	18,2	724,6
2013	2742	214,9	2139,8	8,9	719,2
2014	2879,1	190,9	2274,7	7	757,3
2015	2742,4	162,7	2344,8	0,7	719,7
2016	3543,4	96.8	2617,8	18,5	830,9
2017	3738	200.5	2651,3	0,5	959,6
2018	3914,2	400.1	2711,4	0,8	993,6
2019	4874,9	322,9	2919,5	0,3	12243

Source: official data of the State Statistics Committee of the Republic of Azerbaijan.

4 trend models were constructed, which were specified as follows:

LOG (Indicator) = C(1) + C (2)*@TREND, (1)

where LOG stands for the logarithm, the indicator takes one of the following values {Volume of agricultural products, Investment in AIS, Volume of fixed assets, Volume of value added}. The @TREND variable means time. The regression equation of the dependence of the volume of agricultural products on the volume of fixed assets and investments is presented below by equation (2):

LOG (Volume of agricultural products) =
= C(1) + C (2)*Fixed assets +
+ C (3) * LOG (Investment (-1)) . (2)

In equation (2), the Investment indicator (-1) means that the impact of the investment on the volume of agricultural products occurs 1 year late.

The main results of the econometric models are presented in Table 2.

Table 2

Main econometric results

Equation	Dependent variable	C	Time	Volume of fixed assets	Log (Volume of investment (-1))	Number of observations	Refined coefficient of determination
1	Log (Volume of AIS products)	6.641052	0.095999			20	0.980597
	t- statistics	(192.9965)*	(31.00355)*				
2	Log (Volume of investment in AIS)	2.975260	0.155793			20	0.718242
	t- statistics	(12.08247)*	(7.030915)*				
3	Log (Volume of fixed assets in AIS)	6.617063	0.075833			15	0.926205
	t- statistics	(25.21012)*	(3.259648)*				
4	Log (Volume of value added created in the AIS)	4.960888	0.116807			15	0.963888
	t- statistics	(58.34440)*	(16.23087)*				
5	Log (Volume of AIS products)	6.240468		0.000536	0.101194	14	0.959278
	t- statistics	(32.54395)*		(9.225890)*	(1.805247)**		

*Note. * and * * means that the corresponding coefficient is statistically significant at 99.9% and 90%, respectively.*

According to the constructed trend models, it can be argued that

- the volume of AIS products for 2000-2019 grew by an average of 9.59% per year (at current prices);
- the volume of fixed assets of the AIS for 2005-2019 grew by an average of 7.58% per year (at current prices);
- the volume of investment in AIS for 2000-2019 grew by an average of 15.58% per year (at current prices);
- the volume of value added created in the AIS for 2005-2019 grew by an average of 11.68% per year (at current prices).

Based on the constructed trend models, forecast values for 2020-2025 were constructed for a number of AIS indicators, which are presented in Table 3.

Table 3

Forecast values of a number of AIS indicators, (million mans) at current prices

Index	2020	2021	2022	2023	2024	2025
Volume of AIS products	5750.44	6329.84	6967.62	7669.66	8442.44	9293.09
Volume of fixed assets in AIS	3675.90	3965.51	4277.92	4614.94	4978.52	5370.74
Volume of investment in AIS	516.42	603.48	705.21	824.10	963.03	1125.38
Volume of value added created	1475.91	1658.78	1864.30	2095.29	2354.91	2646.68

The table is constructed by the author on the basis of trend models for a number of AIS indicators.

The regression equation describing the dependence of the volume of AIS production on the volume of fixed assets and investments can be interpreted as follows:

– an increase in the volume of AIS fixed assets by 1 million manats will lead to an increase in AIS production by 0.054%;

– a 1% increase in the volume of investment in AIS will lead to an increase in AIS production by 0.10% with a delay of 1 year;

– changes in the volume of fixed assets and the volume of investment cause changes in the volume of AIS products by 95.93%.

All the constructed models are implemented using the econometric Eviews application software package.

Modern problems of managing economic entities often require the development of extraordinary solutions that are based on accurate mathematical calculations. Practice shows that those entities that widely use mathematical modeling tools in the areas of production and labor organization, marketing, financial and economic assessment and regulation, production and technological planning, crisis management and strategic forecasting, achieve great success and occupy leading positions in a particular business environment. These trends have recently gained particular popularity and

prospects in the field of agriculture. Based on econometric modeling, trend models are constructed for the following indicators:

– products of the agro-industrial sector (AIS);
– the volume of fixed assets of the AIS;
– the volume of investment in the AIS;
– the amount of value added created in the AIS.

With the help of trend models, it was possible to predict the volumes of the above indicators for 2020-2025.

According to the constructed trend models, it can be argued that:

- the volume of AIS products for 2000-2019 grew by an average of 9.59% per year (at current prices);
- the volume of fixed assets of the AIS for 2005-2019 grew by an average of 7.58% per year (at current prices);
- the volume of investment in AIS for 2000-2019 grew by an average of 15.58% per year (at current prices);
- the volume of value added created in the AIS for 2005-2019 grew by an average of 11.68% per year (at current prices);
- the volume of AIS's innovative products decreased by an average of 48.23% annually from 2011 to 2019.

Thus, we note that data on the volume of innovative products are available for 2011-2019, while they were subject to significant fluctuations, which in turn did not allow us to build a statistically significant trend model for this indicator.

In addition, an econometric model of the volume of AIS production is constructed as an explicable variable from such explanatory factors as the volume of AIS fixed assets and the volume of investment in AIS.

All the constructed models are implemented using the econometric Eviews application software package.

The corresponding trend models are presented below:

$$LOG(AIS\_PRODUCTION) = 6.64105210858 + 0.0959987070137*@TREND, \quad (3)$$

$$LOG(ASSETS) = 6.61706344629 + 0.0758331786325*@TREND + [AR(1)=0.719073449491, UNCOND, ESTSMPL="2005 2019"], \quad (4)$$

$$LOG(INVESTMENTS) = 2.97525953741 + 0.155792875161*@TREND, \quad (5)$$

$$LOG(ADDED\_VALUE) = 4.9608882587 + 0.116807196167*@TREND + 0.222861539561*DUMMY\_2009\_2010 + [AR(5)=-0.800010823335, UNCOND,ESTSMPL="2005 2019"], \quad (6)$$

where APO_PRODUCTION denotes the volume of APO production in value terms, ASSETS – the value of fixed assets in AIS, INVESTMENTS – the volume of investment in APO, ADDED_VALUE – the added value created in AIS. @TREND means the time variable, AR(1) – the variable entered in the trend model means the first – order autocorrelation, AR(5) – the variable entered in the trend model means the fifth-order autocorrelation, the variable DUMMY_2009_2010-is a qualitative variable, and takes the values 1 in 2009 and 2010, and in the remaining years the value 0 (zero).

The econometric model of the volume of AIS output from the volume of AIS fixed assets and the volume of investment in AIS is presented below:

$$LOG(AIS\_PRODUCTION) = 6.24046752916 + 0.00053647684835*ASSETS + 0.101193578547*LOG(INVESTMENTS(-1)). \quad (7)$$

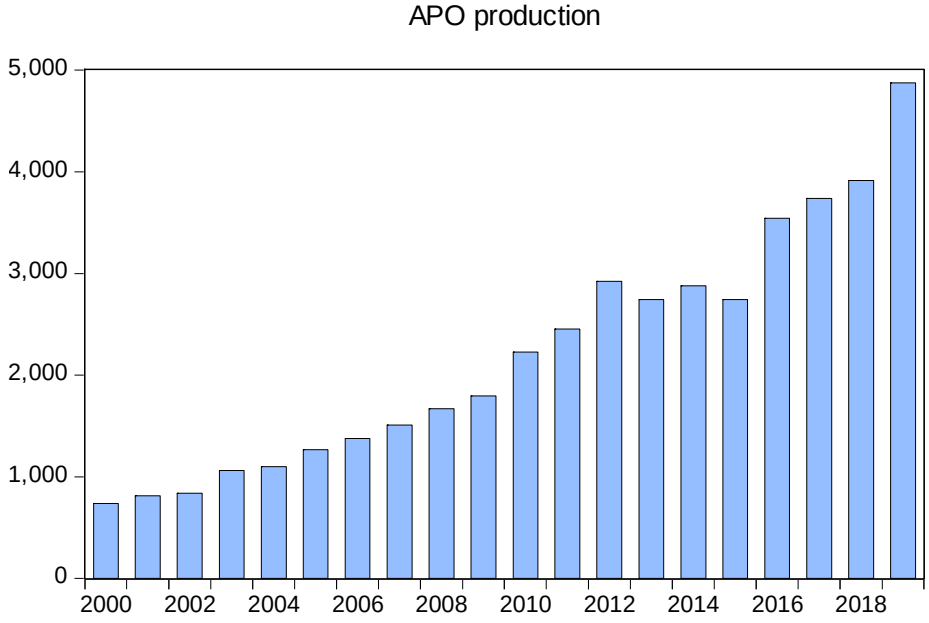
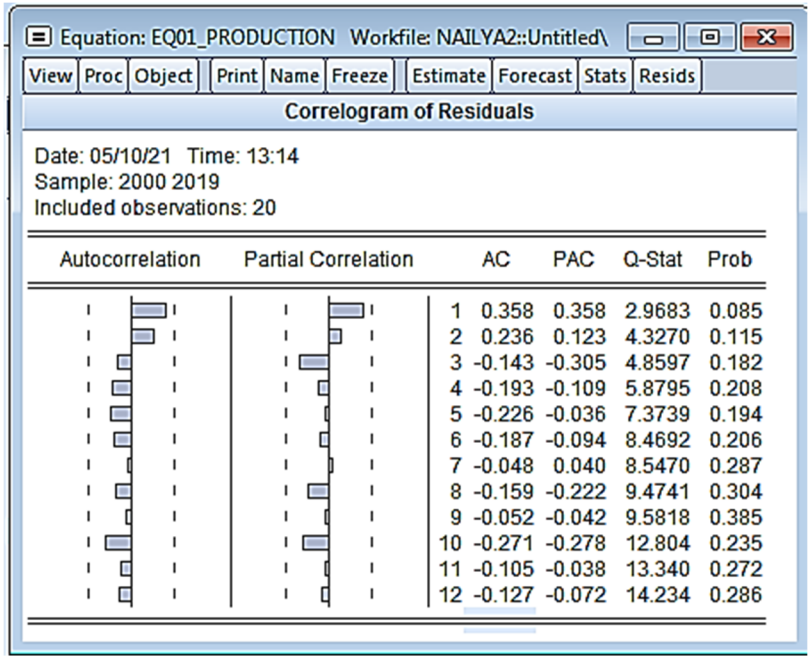


Fig. 1. Volume of AIS products



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Алієва Н. Р. Економіко-математичне моделювання інноваційного процесу в агропромисловій галузі

Сучасні наукові дослідження в агропромисловій сфері все частіше базуються на різних математичних розрахунках. На практиці особливого значення набувають саме економіко-математичні моделі. Особливу цінність і поширення дані методи і підходи отримали саме у виробничому середовищі, але в сучасних умовах виробничо-економічної діяльності все більше галузевих господарюючих суб'єктів стикається з питаннями застосування математичних моделей з метою підвищення ефективності управління інвестиційними ресурсами.

Ключові слова: економетрична модель, обсяг основних фондів, обсяг інвестиції, обсяг доданої вартості, обсяг інноваційної продукції.

Alieva N. Economic and Mathematical Modeling of the Innovation Process in the Agro-Industrial Sector

Modern scientific research in the field of agriculture is increasingly based on various mathematical calculations. In practice, it is the economic and mathematical models that are of particular importance. These methods and approaches are particularly valuable and widespread in the production environment, but in the modern conditions of production and economic activity, more and more industrial economic entities are faced with the application of mathematical models in order to improve the efficiency of investment resource management.

Keywords: econometric model, volume of investment in AIS, volume of fixed assets of AIS, volume of investment in AIS, volume of value added, volume of innovative products of AIS, volume of fixed assets of AIS.

Алиева Н. Р. Экономико-математическое моделирование инновационного процесса в агропромышленной отрасли

Современные научные исследования в агропромышленной сфере все чаще базируются на различных математических расчетах. На практике особую значимость приобретают именно экономико-математические модели. Особую ценность и распространение данные методы и подходы получили именно в производственной среде, но в современных условиях производственно-экономической деятельности все больше отраслевых хозяйствующих субъектов сталкивается с вопросами применения математических моделей с целью повышения эффективности управления инвестиционными ресурсами.

Ключевые слова: эконометрическая модель, объем основных фондов, объем инвестиции, объем добавленной стоимости, объем инновационной продукции.

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